Research Article

Normative data of upper limb motor nerve conduction in Northern Kerala population and effect of height on motor nerve conduction velocity

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Abstract

Background: Nerve conduction study is a part of electrodiagnostic procedures, which is helpful in diagnosis and prognosis of diseases and in finding out the extent and distribution of peripheral nerve injury. The values of nerve conduction studies may vary between different populations owing to ethnic and environmental factors. So, each electrophysiology laboratory need to establish a normative data for its population. Nerve conduction velocity may be affected by many factors such as temperature, height, age, and gender. **Aims and Objective:** To establish normative data for upper limb motor nerve conduction in northern Kerala population and to find out the effect of height on motor nerve conduction velocity. **Materials and Methods:** Motor conduction studies were conducted prospectively in 250 carefully screened subjects of age group 15–50 years. The study group included equal proportion of male and female subjects. Motor amplitude, distal latency, and motor conduction velocity of median and ulnar nerves were performed. All statistical analyses were done with SPSS software, version 16. **Result:** Motor conduction velocities of all tested nerves in both genders were found to be negatively correlated with height. The correlations obtained were statistically significant. **Conclusion:** Normative data for upper limb motor conduction was derived in northern Kerala population. Motor nerve conduction velocities of median and ulnar nerves showed a negative correlation with height.

KEY WORDS: Height; Nerve Conduction Study (NCS); Motor Conduction Study; Motor Conduction Velocity; Compound Muscle Action Potential (CMAP)

Introduction

Electrodiagnostic evaluation refers to physiological expansion of the neurological assessment.[1] Clinical electrodiagnosis constitutes the recording, display, and estimation of action potentials originating from central nervous system (evoked potentials), peripheral nerves (nerve conduction assessments), and muscles (electromyography).[2] Nerve conduction studies (NCSs) are part of electrodiagnostic procedures, which helps in diagnosing abnormalities of nerves. NCSs provide a means of confirming the presence and extent of peripheral nerve damage. These studies can diagnostically aid in patients alleged of experiencing nearly any disorder of peripheral nervous system, comprising disorders of nerve roots, peripheral nerves, and muscle and neuromuscular junctions.[3]

NCSs include motor conduction studies, sensory conduction studies, and late response studies. Motor conduction

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studies are carried out by stimulating motor nerves electrically at two or more different sites and recording from muscle innervated. Standard studies of motor nerve conduction estimate the easily reachable nerves, i.e., ulnar and median nerves in upper extremities. Stimulus of these nerves gives rise to an electrical and a mechanical response in those muscles innervated by the nerve distal to the point of stimulus. The electrical response is called compound muscle action potential (CMAP), which is the summated activity of muscle fibres in the region of recording electrode innervated by the nerve. Amplitude of the response is related to the number of motor units activated.[4]

Motor conduction studies aid the clinician in distinguishing the two chief groups of peripheral diseases: demyelination and axonal degeneration.[5] Demyelination of motor fibers results in reducing the pace of motor conduction across the impacted segment and relative sparing in amplitude of the CMAP with stimulus distal to the site of lesion.[6] Myelinated axon can conduct up to 50 times faster than the fastest unmyelinated fiber owing to saltatory conduction.[7] In contrast, axonal degeneration results lead to reduced amplitude of CMAP distally, although surviving axons conduct normally.[6]

Every electrophysiology laboratory is required to set up the normal values for its population to diagnose abnormal subjects. Misra and Kalita[8] derived normal nerve conduction parameters in north Indian population. Pawar et al.[9] derived normative data of upper limb nerve conduction in central India. Kimura[10] derived normal nerve conduction parameters in western population.[10] To the best of our knowledge, no such studies have been performed in northern Kerala population. So, our laboratory has been using standard values used by Western countries. Hence, the main aim of this study was to provide normal electrophysiological values for upper limb motor nerve conduction parameters in northern Kerala population.

Motor nerve conduction velocity is affected by many factors such as temperature, height, age, and gender. Factors such as temperature and height may vary in different geographic region and in different ethnic groups. Nerve conduction velocity is usually compared with the disease conditions such as diabetes mellitus, carpel tunnel syndrome, and neurological disorders. It is very rarely correlated with physiological variables such as height. So, the effect of height on motor conduction velocity was also checked in this study.

Materials and Methods

This study was done to derive a normative data for upper limb motor nerve conduction in northern Kerala population. It was a cross-sectional observational study done in normal individuals of northern Kerala population. The study was done after obtaining approval from the institutional ethics committee. The study was conducted in 250 normal adults (125 male and 125 female subjects) of age 15 to 50 years from north Kerala. The study lasted for 1 year. Study group included carefully screened normal volunteers from north Kerala region. This included some randomly selected bystanders and hospital staffs. Detailed history was taken, and clinical examination was done before being selected as a subject to rule out any systemic or neuromuscular diseases. Height was measured and noted.

Inclusion Criteria: Normal adults of age 15 to 50 years from north Kerala region were included in this study.

Exclusion Criteria: Individuals with systemic or neuromuscular diseases were excluded from the study. Individuals not belonging to northern Kerala region were also not included this study.

Subjects were acclimatized to standard room temperature (27°C ± 2°C) for 10 min. A RMS EMG EP Mark-II machine was used in the electrophysiology laboratory. Filters were set at 2–5 kHz with a sweep speed of 5 ms per division, for duration of 100 μs. Median and ulnar nerves were tested.

Three surface electrodes were used for recording—active electrode, reference electrode, and ground electrode. The active electrode was placed over the muscle belly. The reference electrode was placed on a nearby tendon or bone away from the muscle. The ground electrode was placed between the stimulator and the active electrode. Grounding is important for obtaining a response that is free of too much artefact. Stimulator consists of two metal pad electrodes placed 1.5 to 3 cm apart. When stimulating, the cathode (black or negative pole) is placed toward the direction in which the nerve is to be stimulated. The conduction was used to ensure electrical contact. All measurements made with supramaximal stimulation.

In median nerve motor conduction study, active electrode was placed on the centre of abductor pollicis brevis. Reference electrode was placed at proximal phalanx of thumb 3–4 cm distal to active electrode. Distal stimulation was given 3 cm proximal to distal wrist crease between tendons of flexor carpi radialis and palmaris longus. Proximal stimulation point was at elbow just lateral to the brachial pulsation.

In ulnar nerve motor conduction study, active electrode was placed on the centre of abductor digiti minimi. Reference electrode was placed distally over fifth digit. Distal stimulation was given 3 cm proximal to distal wrist crease just medial to the flexor carpi ulnaris tendon. Proximal stimulation point was at elbow 3–4 cm distal to the medial epicondyle, with the wrist and the elbow in 90° of flexion.

Motor amplitude, distal latency, and motor conduction velocity were the parameters tested.

Motor Latency: The time taken by electrical impulse to travel from site of stimulation to recording site was measured. This is called latency. Proximal latency is the time interval between proximal stimulation and first deflection from baseline.[11] Similarly, distal latency (DL) is the time interval between distal stimulation and first deflection from baseline.[11] DL was measured in this study. Unit of DL is milliseconds (ms).[2]

Motor Amplitude: The height of the CMAP obtained during nerve conduction studies, which is measured from baseline to

peak, is called motor amplitude. Unit of motor amplitude is millivolts (mV).[2]

Motor Conduction Velocity: By stimulating two or more different locations along same nerve, nerve conduction velocity was calculated. This was done by dividing the length of the nerve segment between two stimulation points by the difference between proximal and distal latencies. Unit of nerve conduction velocity is meter per second (m/s).[8]

All statistical analysis was done with SPSS, version 16. Normal values of motor amplitude, DL, and motor conduction velocity of median and ulnar nerves were found. The correlation of motor conduction velocities with height was studied separately in the two gender group in each side. Pearson correlation coefficients (*r*) were calculated. The value of the correlation coefficient varies from −1 to +1. A value near −1 indicates a strong negative correlation, and a value near +1 indicates a strong positive correlation. All correlations were considered to be significant if *p* value was less than or equal to 0.05.

Result

One hundred twenty-five male subjects with average age 33.54 (SD: 9.64) years and 125 female subjects with average age 35.62 (SD: 7.62) years were examined. Normative data of upper limb motor conduction in northern Kerala population was derived (Table 1).

The values derived in this study were compared with standard values derived in different populations published in the literature (Table 2).

Median motor amplitude derived in this study was close to value obtained by Robinson et al. Median motor DL obtained was lesser than the Indian and Western studies quoted referred in this study. Median motor nerve conduction velocity obtained was comparable with the values in the studies by Kimura and Misra and Kalita. Ulnar motor amplitude and DL obtained was close to those reported by Robinson et al. and Misra and Kalita. The value of ulnar motor nerve conduction velocity was close to that recorded by Kimura.

Correlation of Height With Motor Conduction Velocity: Average height of male subjects in this study was 170.48 cm with standard deviation of 6.74 cm. Average height of female subjects in this study was 162.3 cm with a standard deviation of 5.93 cm. Pearson correlation coefficient was derived (Table 3).

Motor conduction velocities of all tested nerves in both genders were found to be negatively correlated with height. The correlations obtained were statistically significant.

Table 1: Normative data of upper limb motor conduction in northern Kerala population

Nerves	Amplitude (mV), mean ± SD	Distal latency (ms), mean ± SD	Velocity (m/s), mean ± SD
Median	9.66 ± 2.32	3.15 ± 0.18	57.0 ± 1.97
Ulnar	8.06 ± 0.96	2.58 ± 0.14	58.29 ± 1.68

Table 2: Comparison of this study with other published studies

Nerve	Parameter	Robinson et al.[9]	Kimura[10]	Falcon et al.[9]	Kalita and Misra[8]	This study
Median	Amplitude (mV)	9.5 ± 2.9	7.0 ± 3.0	9.2 ± 3.1	8.10 ± 2.62	9.66 ± 2.32
	Distal latency (ms)	3.6 ± 0.4	3.49 ± 0.34	3.5 ± 0.5	3.77 ± 0.40	3.15 ± 0.18
	Velocity (m/s)	54.4 ± 3.8	57.7 ± 4.9	54.4 ± 5.4	58.52 ± 3.76	57.0 ± 1.97
Ulnar	Amplitude (mV)	8.4 ± 2.1	5.7 ±2.0	9.9 ± 1.8	8.51 ± 2.03	8.06 ± 2.90
	Distal latency (ms)	2.9 ± 0.42	2.59 ± 0.39	2.7 ± 0.3	2.59 ± 0.04	2.58 ± 0.14
	Velocity (m/s)	56.3 ± 6.2	58.7 ± 5.1	61.6 ± 4.1	61.45 ± 5.73	58.29 ± 1.68

Table 3: The correlation of height with motor conduction velocity

Nerves	Male subjects		Female subjects	
	r	*p*	*r*	*p*
Right median	−0.630	<0.001*	−0.762	<0.001*
Left median	−0.629	<0.001*	−0.681	<0.001*
Right ulnar	−0.706	<0.001*	−0.729	<0.001*
Left ulnar	−0.691	<0.001*	−0.732	<0.001*

Discussion

Normative data of motor conduction parameters was derived in northern Kerala population. The values obtained were compared with nerve conduction parameters derived in different populations. The results of this study showed many similarities and some dissimilarity with the reported motor conduction variables; the probable reasons could be the true differences among populations and small sample size. The difference among different populations may be owing to technical factors such as difference in room temperature and physiological factors such as difference in average height and age of the population studied. This emphasises the necessity of normative electrodiagnostic data for every laboratory.

References from literature show that age affects electrodiagnostic studies only in extremes of age. The effect of age is most significant from birth to 1 year when myelination is incomplete. In the newborn, nerve conduction velocities are approximately 50% of adult values. By 1 year of age, the velocities reach 75%, and by 3–5 years, myelination is complete and nerve conduction velocities are comparable with adult normative data.[2] Nerve conduction velocity decreases with age owing to decreased number of nerve fiber, a reduction in fiber diameter, and changes in the fiber membrane.[12] But, the values normally change by less than 10 m/s by the sixtieth year or even the eightieth year.[10] The amplitude of the sensory nerve action potential (SNAP) and CMAP may also be affected by age. The reduced amplitude is best related to loss of axons.[12] It is estimated that the SNAP amplitude may decrease by as much as 50% in a 70-year-old patient.[2] Motor CMAP amplitudes decline with aging, although this decrease is much less marked than that seen with SNAP.[13] So, considering the age group selected in this study, age did not exhibit much effect.

Motor conduction velocities of tested nerves were found to be negatively correlated with height, which means that nerve conduction is slower in taller individuals. Many studies in the literature support the observations obtained in the current study. The study done by Campbell et al.[14] showed that peroneal and sural conduction velocities varied inversely with height. The study conducted by Bodofsky[15] showed that ulnar motor conduction velocity appears to be inversely proportional to the square root of height. The studies done by Thakur et al.[16] showed motor conduction velocity of ulnar nerve is negatively correlated with height. The study of Patel et al.[17] pointed out a negative correlation between upper limb motor conduction velocity and height.[17]

The nerve impulse propagates faster in the proximal than in the distal nerve segment. Nerve conduction is faster in upper limb nerves compared with lower limb nerves. It suggests that shorter nerves conduct faster than longer nerves. The reason for this physiological difference may be abrupt distal tapering of axons, shorter internodal distance, and progressive reduction in axonal diameter.[8] This mode of tapering may help in explaining the decrements in conduction velocity from proximal to distal nerve segments and from upper to lower extremities, which have been observed in clinical electromyography long back. Clinical recognition of this height effect is important, or else, one would label an individual as abnormal with mildly slowed peripheral nerve conduction velocity solely related to large stature.

Over the years, electrophysiological methods have provided chief contributions to the knowledge of peripheral nerve function in health and disease states. Although there are certain constraints, these procedures can provide diagnostically relevant data if used sensibly in suitable clinical contexts. The reference values obtained in this study can be used to diagnose nerve conduction abnormalities of this population.

Limitations of the Study: As age is an important factor, which affects motor nerve conduction parameters, it would have been better to report the nerve conduction parameters in different age groups. Even though a negative correlation was established between height and nerve conduction velocity, an age-adjusted reference data was not created in this study. If sample size was more, a more representative data would have been obtained.

Conclusion

Normative data of motor conduction parameters was established in northern Kerala population. This can be used as a reference data to find out motor nerve conduction abnormalities in the population. The results of this study showed many similarities and some dissimilarity with the reported NCS variables; the probable reasons could be the true differences among populations and small sample size. Motor conduction velocity of median and ulnar nerves was found to be negatively correlated with height. So, the diagnostic conclusions made from the nerve conduction velocity without making corrections for the height may be invalid in patients who are taller and shorter than the average individuals. Hence, for proper diagnosis of nerve conduction abnormalities, a height-adjusted reference data must be created in future by a large population study.

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